

Two Dimensional Power Spectral Density Measurements of X-ray Optics with the Micromap Interferometric Microscope

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The interferometric microscope has become a basic metrology tool for highly accurate testing of the surface finish of X-ray optics with sub-Angstrom rms roughness. The standard list of output parameters of an interferometric microscope measurement (such as the Micromap-570) includes values of roughness averaged over an area and along a sample line. However sophisticated X-ray scattering calculations require more rigorous information about the optics. One of the most insightful approaches to the calculation is based on the two-dimensional (2D) power spectral density (PSD) distribution, allowing for the evaluation of three-dimensional distributions of X-rays scattered by the optics.

A straightforward attempt to transform the area distribution of the residual surface heights available from the interferometric microscope data file into a 2D PSD distribution fails due to the spectral distortion in the PSD caused by an unknown spatial frequency response function of the instrument.

For the case of the Micromap-570 measurement, the PSD spectral distortion appears as a significant difference between the tangential and sagittal PSD spectra deduced from the 2D PSD distribution. A detailed investigation of the origin of the anisotropy was performed that indicated the read-out asymmetry of the CCD camera and the necessary correction of the asymmetry by the software algorithm caused the problem.

The main results of this investigation are additional software and a procedure developed for correcting the Micromap-570 2D PSD measurements. The correction employs a spatial frequency response function deduced analytically based on experimentally confirmed assumptions about the origin of the resolution anisotropy. The deduced spatial frequency response function has only one free parameter, the width of the gate-shaped apparatus function which is equal for both directions. The developed procedure has been applied to correct the 2D PSD distribution for the Micromap-570 self-test measurement, which should give a white-noise 1D PSD spectrum independent of spatial frequency. The resolution width corresponding to the best fit was found to be 1.35 pixels. The effectiveness of the correction is demonstrated with a number of PSD measurements with different X-ray optics. In particular, the developed PSD procedure was successfully applied to measure the spatial distribution of groove density of an X-ray grating.

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